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Improvement in Bituminous Surface Course Using Waste Plastic in Snow Bound Areas

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Abstract: ***Transportation is an essential component for the infrastructure of all the countries. The economy and economic status of any country is determined by its network of roads, railways, waterways, airways, pipes and ports. . In the northern areas of our country, roads are the most important source of connectivity. Due to cold weather conditions which include factors like snow, rain, frost, and these roads suffer excessive damage and thus hamper the movement of people as well as goods across these parts of the country. To improve the conditions of the road connectivity in such areas huge amount of money is being invested, but the end results don't come as satisfactory as they should come. To prevent the damage to these roads by such factors no particular method has been developed. Use of plastic in bituminous mixes can be of importance in curbing the excess damage to roads in cold weather conditions. Waste plastic roads have been used in some parts of the country with a varying degree of success. Waste plastic roads have various advantages over normal roads which can be of great importance in these parts of the country.***
Keywords: Subzero Temperature, roads, design, waste plastic, bitumen.

I. INTRODUCTION.

The road network of India is the second biggest in the globe. It is responsible for carrying about more than half of the goods of country (60%) and the majority of passengers as well(85%).The total length of roadways is estimated as 5.4million Km. In the northern areas of the country, roads are the most important source of connectivity. Due to cold weather conditions which include factors like snow, rain, frost, and these roads suffer excessive damage and thus hamper the movement of people as well as goods across these parts of the country. To improve the conditions of the road connectivity in such areas huge amount of money is being invested. The central government has awarded a contract of Rs 23,000 crore for building 5 all-weather tunnels in Jammu and Kashmir by 2024.Huge reserves of money have been invested in the four laning of nation highways in the state of Himachal Pradesh .Along with the construction of these new roads, the maintenance of such roads and tunnels is important for increasing their life span. Cold weather conditions provide the northern parts of our country with some unique problems which aren't problematic in other parts of the country. In the Cold regions of our country such as Jammu and Kashmir, Himachal Pradesh and Uttrakhand, the subzero temperature are severely hazardous to road networks. The freezing of moisture in the pores and regular and long contacts with snow also proves damaging to road networks. To prevent the damage to these roads by such factors no particular method has been developed. Use of plastic in bituminous mixes can be of importance in curbing the excess damage to roads in cold weather conditions. Waste plastic roads have been used in some parts of the country with a varying degree of success. Waste plastic roads have various advantages over normal roads which can be of great importance in these parts of the country. . There are various factors which influence the flexible pavement performances. These include the properties which the components have and also their proportions which are utilized in mixes. The modifications in Bitumen can be carried out by addition of various types of additives. Polymers can be categorized as one of the types of additive. By the addition of Polymers to the Bitumen , the temperature susceptibility and also the stiffness gets increased .Due to this increase in stiffness, the resistance of the mix to rutting in hot climates is generally improved and thus we can use a comparatively softer base bitumen ,which results in improved performances at low temperatures.

II. METHOLODOGY

A. Need of the Present Study

Road networks in India are vastly expanding. Thousands of crores of money is being invested in the maintenance and repair of these roads. The maintenance and repair of such roads in cold states of Jammu Kashmir along with Himachal Pradesh and some other northern regions is becoming hectic and troublesome due to the frequent stripping and pothole occurrence as a result of snowfall and torrential rains which create havoc in these regions. The amount of plastic present provides a viable option to look for an alternative for the normal mixes by replacing them with modified mixes. \

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This can lead to a significant reduction in the maintenance and repair costs and even the construction cost of the roads in such areas along with the visible gains in the form of durability, strength and increased service life.

The present study deals with enhancing the properties of modified mixes to deal with the problems existing in such areas.

B. Objectives of Study

1) To determine the optimum amount of plastic waste for addition to bituminous mix namely Bituminous Concrete.
2) To study the effects of addition of plastic in the desirable properties of Bituminous Concrete.
3) To evaluate the effect of Freeze Thaw phenomenon on various properties of bituminous mix .e.g % air voids, % optimum binder content.
4) To establish parameters for evaluation of durability and loss of properties for bituminous mixes in colder regions.

C. Methodology Introduction

The methods used in achievement of the objectives have been discussed in this chapter.
Discussions with regard to the test procedures and materials utilized are also provided.

III. RESEARCH METHODOLOGY

So as to achieve the whole extent of study, Evaluation of mixes shall be made using Marshall Method of Design. For this purpose various materials viz aggregates, binder, waste PET water bottles were used. Optimum binder content was selected. Grading was done according to the specifications. The procedure involved in this study is as:

1) The material to be used were collected from the nearby area of Srinagar.
2) The waste plastic material was then collected in the shredded form.
3) Bitumen of grade VG-10 was to be used.
4) Optimum binder content for normal mix was determined.
5) Optimum plastic waste was kept as 6-8% for addition to the mix.
6) The effects on the mix by the addition of waste plastic was examined by Marshall Stability Tests.
7) Testing of Samples prepared with Waste Plastic will be done at -3 degree.
8) Samples shall be prepared by the addition of Waste plastic .
9) The samples were subjected to multiple cycles freeze thaw and then tested. The number of cycles can be 9 & 18 cycles.
10) The results obtained were then compared to examine the effects of addition of plastic.
11) From the above test information, the test outcomes might be investigated to make reasonable interpretation regarding our objective.
12) The tests for the study will be completed at Civil Engineering Department, SSM college of Engineering and Road research lab Srinagar.

IV. RESULTS AND ANALYSIS

A. Properties of Various Materials Used In the Study.

For performing this study various materials were used.
These are as:

1) Plastic waste(PET water bottles)
2) Aggregates , size 13.2mm
3) VG10 bitumen.


Fig 1 waste PET


Fig 2 aggregates


Fig 3 bitumen

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According to MORTH various tests conducted on aggregates and bitumen are as

Table 1: Physical Properties of Aggregates

Physical Properties	13.2mm	Requirements as per MORTH(Revision 5th)
Specific Gravity	2.7	2.6-2.8
Elongation Index (%)	13	Max 30% (combined)
Flakiness Index (%)	12	
Impact Value (%)	17	Max 24%
Water Absorption (%)	0.8	Max 2%
Stripping Value (%)	2-3	<5%
Aggregate crushing value (%)	3	Not mentioned
Abrasion value	28	Max 30%

Table .2: Physical Properties of Binder

Properties	VG-10 Grade		Test Method
	Determined	Required	
Penetration	89	80-100	IS: 1203-1978
Softening point	41.4	40 min.	IS : 1205-1978
Specific gravity	1.3	0.99 min.	IS: 1202-1978

B. Determination of Job mix formula for Bituminous Concrete control mix by Marshall Method.

The Grading of different aggregates was done for obtaining virgin mix. The results are as shown in following table:

Table 3: Grading of Aggregates for Control Mix

IS Sieve Size	% passing (required)	% passing 19mm	% passing 13.2mm	% passing Stone dust	% passing Cement	Grading
19mm	90-100	90.1	100	100	100	98.1
13.2mm	59-79	12	99	100	100	76.34
9.5mm	52-72	2.23	77.1	100	100	70.1
4.75mm	35-55	0.07	5	97.1	100	45.32
2.36mm	28-44	0	0.03	76.4	100	31.40
1.18mm	20-34	0	0	62.3	100	27.1
600mm	15-27	0	0	41.8	100	22.5
300mm	10-20	0	0	33.0	99	17.2
150mm	5-13	0	0	21.2	97.9	8.97
75mm	2-8	0	0	32.9	99	7.3

After grading of aggregates, ratio of the blend is calculated. It was done using a programme in Ms-excel and the ratio used was 55:42:3

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C. Quantity of Aggregates used

After determining the ratio of aggregate blend, the quantity of aggregates required for the mix is calculated. This is given in the following table .

Table 4: Percentage and Quantity of Aggregates for Control Mix

Size of Aggregates	Percentage used	Weight of Aggregates(grams)
13.2	55%	660
Stone Dust	42%	504
Cement	3%	36

D. Marshall Stability Test results for Control Mix

Table 5: Marshall Stability Test results for Control Mix

Bitumen Content	5.5%	6%	6.5%
Specific Gravity of Bitumen	1.0	1.0	1.0
Density (g/cc)	2.321	2.356	2.326
Specific Gravity of Aggregate Blend	2.68	2.68	2.68
Volume of Bitumen, V_b(%)	12.006	12.597	14.01
Volume of Aggregate, V_a(%)	82.21	82.65	81.68
Voids in Mineral Aggregate, VMA (%)	17.79	17.35	18.32
Voids Filled with Bitumen, VFB (%)	67.48	72.60	76.47
Air Voids, %	5.784	4.753	4.31
Stability, kg	1767	2132	1925
Flow Value, mm	3.46	3.73	4.25

E. Determination of Optimum Binder Content

After performing Marshall Stability Test, the optimum binder content was known to be 6%.The quantity of bitumen in accordance to its percentage was calculated as 72grams.

F. Determination of Optimum waste plastic Content.

Like above , optimum Waste plastic content was found to be 6%. And marshal test was conducted.

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G. Marshall Stability Test results for Mix with 6% WPB

Table 6: Marshall Stability Test results for Mix with 6% WPB

Bitumen Content	5.5%	6%	6.5%
Specific Gravity of Bitumen	1.0	1.0	1.0
Density (g/cc)	2.293	2.284	2.279
Specific Gravity of Aggregate Blend	2.557	2.557	2.557
Volume of Bitumen, V_b(%)	12.45	12.927	12.91
Volume of Aggregate, V_a(%)	84.80	84.26	84.15
Voids in Mineral Aggregate, VMA (%)	15.2	15.74	15.85
Voids Filled with Bitumen, VFB (%)	81.9	82.08	81.45
Air Voids, %	2.75	2.82	2.79
Stability, kg	2462.4	2885	2891
Flow Value, mm	3.812	3.98	4.412



Fig 3 waste PET added to aggregates



fig 4 samples with varying bitumen content

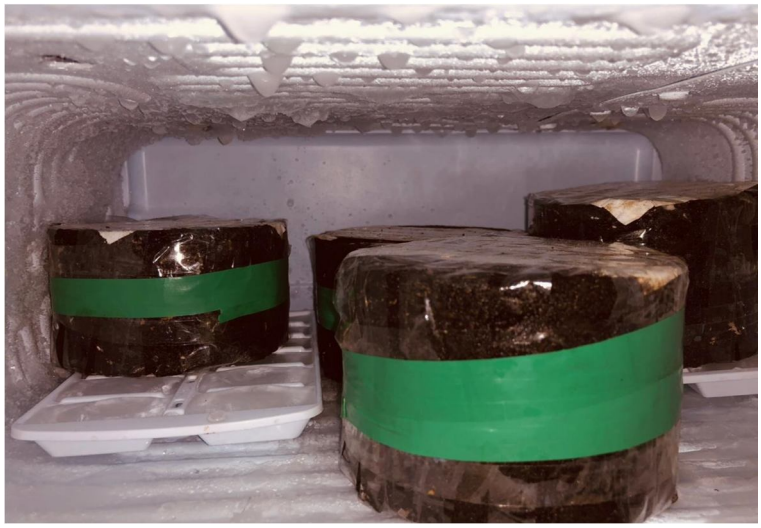


Fig 5 , samples under freezing

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H. Tests results after Repetitive Freeze Thaw cycles (9,18 & 21 days)

Samples were made using job mix formula for control mix at bitumen content of 6%, mix with 6% Waste PET .Samples were subjected to repeated freeze thaw cycles for 9, 18 and 21 days The results of tests performed are as:

Table 7, Results after 9 days

Bitumen Content (9 days)	Control mix	PET 6%
Specific Gravity of Bitumen	1.0	1.0
Density (g/cc)	2.34	2.285
Specific Gravity of Aggregate Blend	2.65	2.41
Volume of Bitumen, V_b(%)	13.170	12.933
Volume of Aggregate, V_a(%)	81.91	84.30
Voids in Mineral Aggregate, VMA (%)	17.1	14.6
Voids Filled with Bitumen, VFB (%)	69.7	80.3
Air Voids, %	5.1	3.61
Stability, kg	1578	2572
Flow Value, mm	2.65	3.4

Table 8, results after 18 days

Bitumen Content (18 days)	Control mix	PET 6%
Specific Gravity of Bitumen	1.0	1.0
Density (g/cc)	2.327	2.285
Specific Gravity of Aggregate Blend	2.68	2.557
Volume of Bitumen, V_b(%)	13.170	12.933
Volume of Aggregate, V_a(%)	81.91	84.30
Voids in Mineral Aggregate, VMA (%)	19.09	14.7
Voids Filled with Bitumen, VFB (%)	72.65	83.37
Air Voids, %	4.07	2.19
Stability, kg	1110	2004
Flow value mm	2.45	3.0

Table 9 ; TEST results after 27 days

Bitumen content	Control mix	PET mix
Stability, kg	515	1135
Flow value , mm	2.69	2.99

V. CONCLUSION

A. Mixes having waste PET water bottles can be utilized in the construction of BC pavements. Mixes with 6% PET show good results and can hence replace aggregate in virgin mixes.

B. The optimum amount of PET for mix in BC was found to be 6% at a bitumen content of 6%

C. It was observed that after comparing the results of the mixes prepared by the addition of PET provided better results in terms of Retained Marshall stability and Marshall Quotient.

D. The comparative study of the results obtained for mixes with 6% PET and control mix after 9, 18 & 21 days repeated Freeze Thaw cycles also indicate much better Stability and Marshall quotient values for Mix with 6% PET.

E. By exposing the mix to 21 repetitive Freeze Thaw cycles, majority of the Stability is lost by the both Control Mix and Mix with PET.

F. From the observation of results, it can be concluded that mixes with 6% WPB have greater durability and Strength as compared to the mixes with control mix.

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G. .It was observed that control mix after being subjected to repeated Freeze Thaw cycles can lose more than 50% of its original strength; hence modification to the mix should be done by addition of 6% PET which highly enhances the strength of the mix.

H. The mixes with 6% PET even after 21 Freeze exhibit stability values similar to that of control mix under ideal conditions. Thus, it can be concluded that 6% PET should be added to the mix for use in places having low day and night temperatures.

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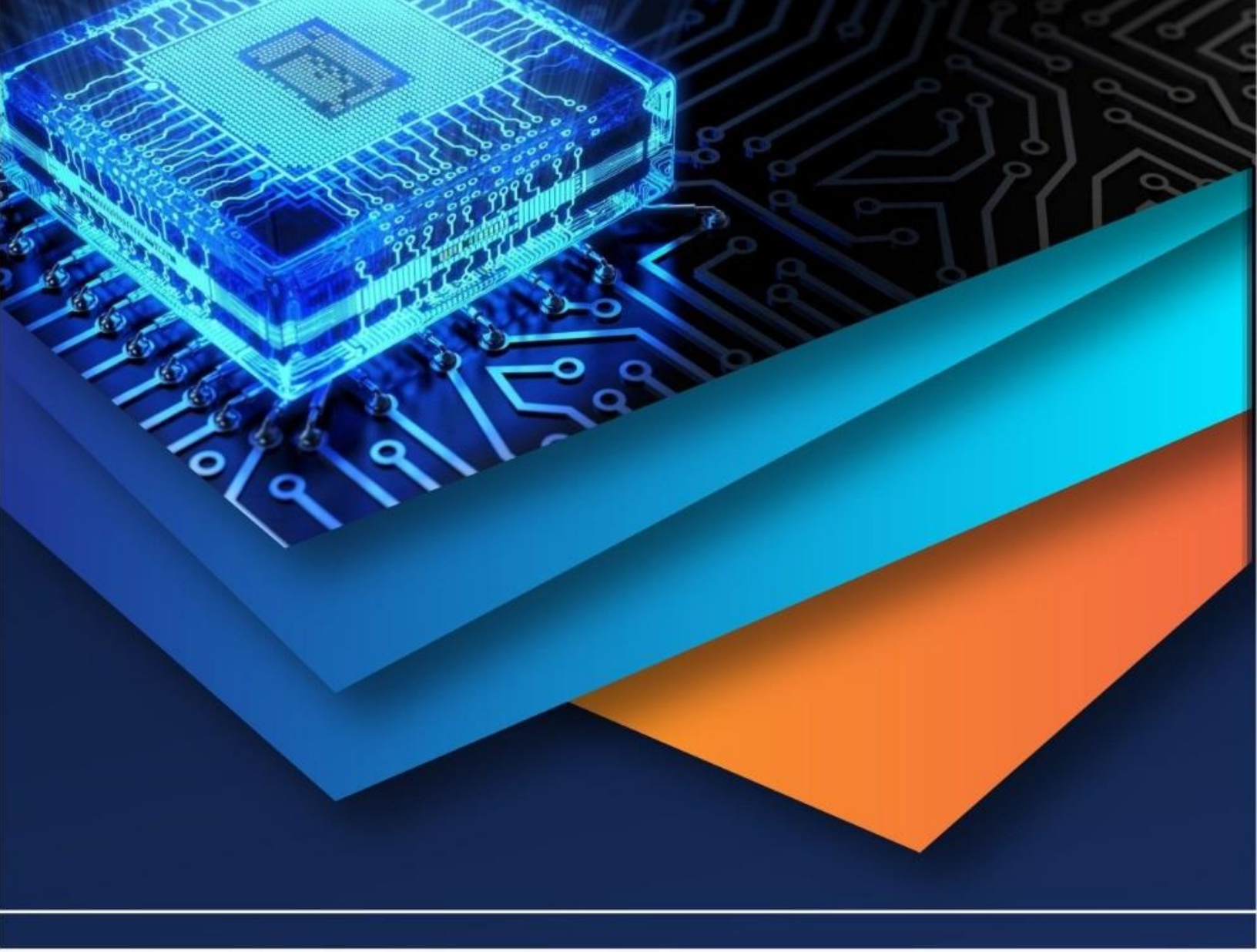
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